1. Scraper

```
%pip install selenium
%pip install webdriver-manager
```

1.1 imports + global variables

```python
from selenium import webdriver
from selenium.webdriver.chrome.service import Service as ChromeService
from webdriver_manager.chrome import ChromeDriverManager
from selenium.webdriver.common.by import By
import time
import urllib
import os

football_folder_name = "football_folder"
basketball_folder_name = "basketball_folder"
tennis_folder_name = "tennis_folder"
golf_folder_name = "golf_folder"
volleyball_folder_name = "volleyball_folder"

football_photo_name = "football"
basketball_photo_name = "basketball"
tennisball_photo_name = "tennisball"
golfball_photo_name = "golfball"
volleyball_photo_name = "volleyball"
```

1.2 download images

```python
def download_images(search_term, safe_folder, num_images, safe_word):
    driver = webdriver.Chrome(service=ChromeService(ChromeDriverManager().install()))
    image_succesfull = 0

    parent_dir = "c:/Users/Jarne/Documents/schooljaar 2023-2024/ai/task3/datasets"
    path = os.path.join(parent_dir, safe_folder)
    print(path)

    try:
        if not os.path.exists(path):
          print(f"Creating folder: {path}")
          os.makedirs(path)

        search_url = f"https://www.google.com/search?q={search_term}&source=lnms&tbm=isch"
        driver.get(search_url)

        # Wait for the cookie popup and accept cookies
        time.sleep(2)
        driver.find_element(By.XPATH, '//button[@aria-label="Reject all"]').click()

        # Scroll down to load more images
        for _ in range(10):
            driver.execute_script("window.scrollTo(0, document.body.scrollHeight);")
            time.sleep(1)
            try:
                driver.find_element(By.XPATH, '//input[@value="Show more results"]').click()
                time.sleep(1)
            except:
                pass

        # Find and download images
        images = driver.find_elements(By.CSS_SELECTOR, '.rg_i.Q4LuWd')

        while image_succesfull < num_images:
            for index, image in enumerate(images[:num_images]):
                src = image.get_attribute('src')
                if src:
                    urllib.request.urlretrieve(src, os.path.join(path, f'{safe_word}{image_succesfull}.jpg'))
                    print(f'Downloaded: {safe_word}{image_succesfull}.jpg')
                    image_succesfull += 1
                    if image_succesfull >= num_images:
                        break
    except Exception as e:
        print(f'An error occurred: {e}')
    finally:
        driver.quit()

def main():
  download_images("soccer ball", football_folder_name, 5000, football_photo_name)
  download_images("basketball ball", basketball_folder_name, 5000, basketball_photo_name)
  download_images("tennis ball", tennis_folder_name, 5000, tennisball_photo_name)
  download_images("golf ball", golf_folder_name, 5000, golfball_photo_name)
  download_images("volleyball ball", volleyball_folder_name, 5000, volleyball_photo_name)

if __name__ == '__main__':
    main()
```

2. EDA & Data prep

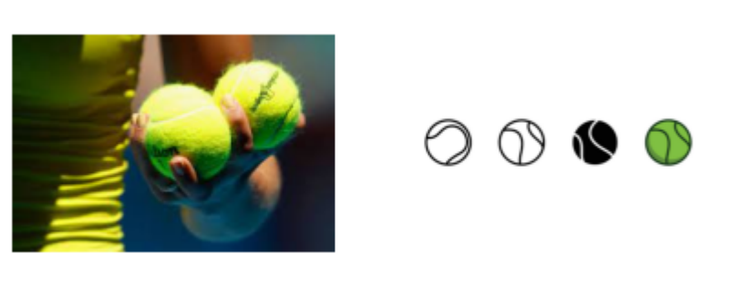
2.1 EDA + imports

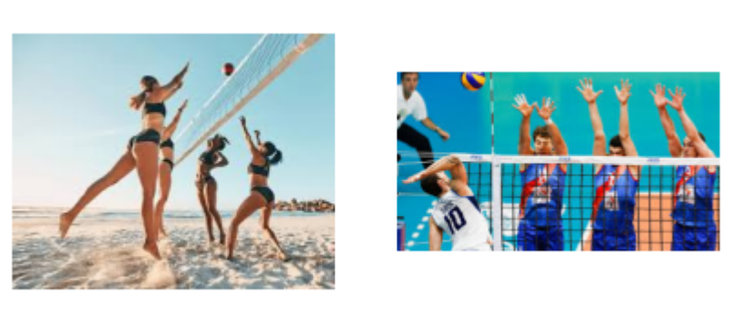
```
%pip install matplotlib
%pip install numpy
%pip install opencv-python opencv-contrib-python
```

```python
import cv2
import numpy as np
import matplotlib.pyplot as plt
%matplotlib inline
import random
```

```python
def count_images_in_folders(safe_folder):
    parent_dir = "C:/Users/Jarne/Documents/schooljaar 2023-2024/ai/task3/datasets"
    path = os.path.join(parent_dir, safe_folder)

    if not os.path.exists(path) or not os.path.isdir(path):
        print(f"Invalid directory: {path}")
        return

    classes = [class_name for class_name in os.listdir(path) if os.path.isfile(os.path.join(path, class_name))]

    print(f"The folder: {safe_folder} has: {len(classes)} images")

def showRandom2Images(safe_folder, photo_name):
    parent_dir = "C:/Users/Jarne/Documents/schooljaar 2023-2024/ai/task3/datasets"
    path = os.path.join(parent_dir, safe_folder)

    images = []

    for i in range(2):
        rnd = random.randint(0,len([class_name for class_name in os.listdir(path) if os.path.isfile(os.path.join(path, class_name))])-1)
        img_orig = cv2.imread(path + '/' + photo_name + str(rnd) + '.jpg')
        img_rgb = cv2.cvtColor(img_orig, cv2.COLOR_BGR2RGB)
        images.append(img_rgb)

    plt.figure(figsize = (5, 10))
    for i in range(2):
        plt.subplot(1,2 ,i+1)
        plt.imshow(images[i])
        plt.axis('off')

def main():
    count_images_in_folders(football_folder_name)
    count_images_in_folders(basketball_folder_name)
    count_images_in_folders(tennis_folder_name)
    count_images_in_folders(golf_folder_name)
    count_images_in_folders(volleyball_folder_name)

    showRandom2Images(football_folder_name, football_photo_name)
    showRandom2Images(basketball_folder_name, basketball_photo_name)
    showRandom2Images(tennis_folder_name, tennisball_photo_name)
    showRandom2Images(golf_folder_name, golfball_photo_name)
    showRandom2Images(volleyball_folder_name, volleyball_photo_name)

if __name__ == '__main__':
    main()
```

```
The folder: football_folder has: 5000 images
The folder: basketball_folder has: 5000 images
The folder: tennis_folder has: 5000 images
The folder: golf_folder has: 5000 images
The folder: volleyball_folder has: 5000 images
```





2.2 Data prep + imports

```python
import os
import random
import shutil
```

```python
def split_data(source_folder, training_folder, test_folder, test_percentage=0.1):
    classes = os.listdir(source_folder)

    for class_name in classes:
        class_path = os.path.join(source_folder, class_name)
        images = os.listdir(class_path)

        # Calculate the number of images for the test set
        test_size = int(len(images) * test_percentage)

        # Create destination folders
        train_class_path = os.path.join(training_folder, class_name)
        test_class_path = os.path.join(test_folder, class_name)

        if not os.path.exists(train_class_path):
            os.makedirs(train_class_path)

        if not os.path.exists(test_class_path):
            os.makedirs(test_class_path)

        # Randomly shuffle the list of images
        random.shuffle(images)

        # Move the first 'test_size' images to the test set folder
        for image_name in images[:test_size]:
            source_path = os.path.join(class_path, image_name)
            dest_path = os.path.join(test_class_path, image_name)
            shutil.move(source_path, dest_path)

        # Move the remaining images to the training set folder
        for image_name in images[test_size:]:
            source_path = os.path.join(class_path, image_name)
            dest_path = os.path.join(train_class_path, image_name)
            shutil.move(source_path, dest_path)

    # Delete the original class folders
    for class_name in classes:
        class_path = os.path.join(source_folder, class_name)
        shutil.rmtree(class_path)

def main():
    source_folder = "c:/Users/Jarne/Documents/schooljaar 2023-2024/ai/task3/datasets"
    training_folder = "c:/Users/Jarne/Documents/schooljaar 2023-2024/ai/task3/datasets/training_set"
    test_folder = "c:/Users/Jarne/Documents/schooljaar 2023-2024/ai/task3/datasets/test_set"

    split_data(source_folder, training_folder, test_folder, test_percentage=0.1)

if __name__ == '__main__':
    main()
```

3. CNN network

```
%pip install tensorflow
```

```python
import numpy as np
import matplotlib.pyplot as plt
import tensorflow as tf
from tensorflow import keras
from tensorflow.keras import optimizers
from tensorflow.keras import layers
from keras.preprocessing.image import ImageDataGenerator
```

```python
NUM_CLASSES = 5
IMG_SIZE = 64
# There is no shearing option anymore, but there is a translation option
HEIGTH_FACTOR = 0.2
WIDTH_FACTOR = 0.2

# Create a sequential model with a list of layers
model = tf.keras.Sequential([
  # Add a resizing layer to resize the images to a consistent shape
  layers.Resizing(IMG_SIZE, IMG_SIZE),
  # Add a rescaling layer to rescale the pixel values to the [0, 1] range
  layers.Rescaling(1./255),
  # Add some data augmentation layers to apply random transformations during training
  layers.RandomFlip("horizontal"),
  layers.RandomTranslation(HEIGTH_FACTOR,WIDTH_FACTOR),
  layers.RandomZoom(0.2),

  layers.Conv2D(32, (3, 3), input_shape = (64, 64, 3), activation="relu"),
  layers.MaxPooling2D((2, 2)),
  layers.Dropout(0.2),
  layers.Conv2D(32, (3, 3), activation="relu"),
  layers.MaxPooling2D((2, 2)),
  layers.Dropout(0.2),
  layers.Flatten(),
  layers.Dense(128, activation="relu"),
  layers.Dense(NUM_CLASSES, activation="softmax")
])

# Compile and train your model as usual
model.compile(optimizer = 'adam', loss = 'categorical_crossentropy', metrics = ['accuracy'])
```

```python
from keras.utils import image_dataset_from_directory
# Set the parameters for your data
batch_size = 32
image_size = (64, 64)
validation_split = 0.2

# Create the training dataset from the 'train' directory
train_ds = image_dataset_from_directory(
    directory='datasets/training_set',
    labels='inferred',
    label_mode='categorical',
    batch_size=batch_size,
    image_size=image_size,
    validation_split=validation_split,
    subset='training',
    seed=123
)

# Create the validation dataset from the 'train' directory
validation_ds = image_dataset_from_directory(
    directory='datasets/training_set',
    labels='inferred',
    label_mode='categorical',
    batch_size=batch_size,
    image_size=image_size,
    validation_split=validation_split,
    subset='validation',
    seed=123
)

# Create the testing dataset from the 'test' directory
test_ds = image_dataset_from_directory(
    directory='datasets/test_set',
    labels='inferred',
    label_mode='categorical',
    batch_size=batch_size,
    image_size=image_size
)
```

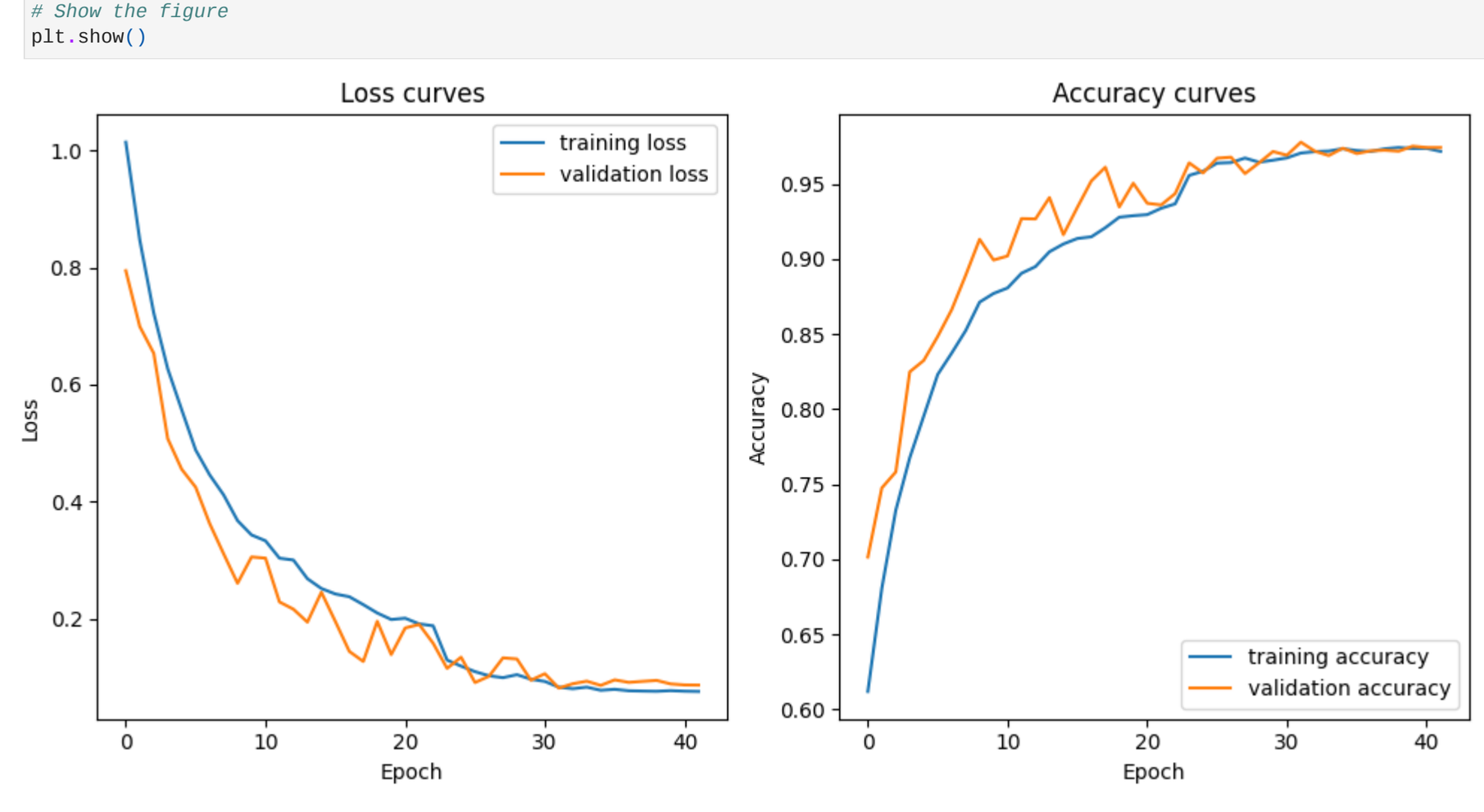
```
Found 22500 files belonging to 5 classes.
Using 18000 files for training.
Found 22500 files belonging to 5 classes.
Using 4500 files for validation.
Found 2500 files belonging to 5 classes.
```

4. Training model

```python
steps_per_epoch = len(train_ds)
history = model.fit(train_ds,
                validation_data = validation_ds,
                steps_per_epoch = steps_per_epoch,
                epochs = 100,
                verbose=1,  # Set to 1 to see training progress
                callbacks=[
                  # Add early stopping to prevent overfitting
                  tf.keras.callbacks.EarlyStopping(monitor='val_loss', patience=10, restore_best_weights=True),

                  # Add learning rate scheduling
                  tf.keras.callbacks.ReduceLROnPlateau(monitor='val_loss', factor=0.2, patience=5, min_lr=1e-7),

                  # Add model checkpoint to save the best weights during training
                  tf.keras.callbacks.ModelCheckpoint(filepath='best_model.h5', monitor='val_loss', save_best_only=True)
              ]
                )
```

```
Epoch 1/100
563/563 [==============================] - 21s 37ms/step - loss: 1.0141 - accuracy: 0.6121 - val_loss: 0.7945 - val_accuracy: 0.7016 - lr: 0.0010
Epoch 2/100
  1/563 [..............................] - ETA: 1:02 - loss: 0.8696 - accuracy: 0.6875
c:\Users\Jarne\AppData\Local\Programs\Python\Python310\lib\site-packages\keras\src\engine\training.py:3103: UserWarning: You are saving your model as an HDF5 file via `model.save()`. This file format is considered legacy. We recommend using instead the native Keras format, e.g. `model.save('my_model.keras')`.
  saving_api.save_model(
563/563 [==============================] - 20s 36ms/step - loss: 0.8469 - accuracy: 0.6807 - val_loss: 0.6991 - val_accuracy: 0.7476 - lr: 0.0010
Epoch 3/100
563/563 [==============================] - 21s 37ms/step - loss: 0.7223 - accuracy: 0.7327 - val_loss: 0.6534 - val_accuracy: 0.7582 - lr: 0.0010
Epoch 4/100
563/563 [==============================] - 22s 38ms/step - loss: 0.6270 - accuracy: 0.7677 - val_loss: 0.5075 - val_accuracy: 0.8249 - lr: 0.0010
Epoch 5/100
563/563 [==============================] - 22s 39ms/step - loss: 0.5569 - accuracy: 0.7954 - val_loss: 0.4553 - val_accuracy: 0.8324 - lr: 0.0010
Epoch 6/100
563/563 [==============================] - 21s 38ms/step - loss: 0.4882 - accuracy: 0.8231 - val_loss: 0.4246 - val_accuracy: 0.8484 - lr: 0.0010
Epoch 7/100
563/563 [==============================] - 21s 37ms/step - loss: 0.4458 - accuracy: 0.8373 - val_loss: 0.3626 - val_accuracy: 0.8662 - lr: 0.0010
Epoch 8/100
563/563 [==============================] - 21s 37ms/step - loss: 0.4115 - accuracy: 0.8523 - val_loss: 0.3109 - val_accuracy: 0.8891 - lr: 0.0010
Epoch 9/100
563/563 [==============================] - 22s 38ms/step - loss: 0.3675 - accuracy: 0.8713 - val_loss: 0.2605 - val_accuracy: 0.9131 - lr: 0.0010
Epoch 10/100
563/563 [==============================] - 21s 38ms/step - loss: 0.3430 - accuracy: 0.8771 - val_loss: 0.3054 - val_accuracy: 0.8993 - lr: 0.0010
Epoch 11/100
563/563 [==============================] - 21s 37ms/step - loss: 0.3330 - accuracy: 0.8807 - val_loss: 0.3034 - val_accuracy: 0.9020 - lr: 0.0010
Epoch 12/100
563/563 [==============================] - 22s 38ms/step - loss: 0.3033 - accuracy: 0.8905 - val_loss: 0.2286 - val_accuracy: 0.9269 - lr: 0.0010
Epoch 13/100
563/563 [==============================] - 22s 39ms/step - loss: 0.3001 - accuracy: 0.8949 - val_loss: 0.2162 - val_accuracy: 0.9267 - lr: 0.0010
Epoch 14/100
563/563 [==============================] - 21s 38ms/step - loss: 0.2683 - accuracy: 0.9048 - val_loss: 0.1941 - val_accuracy: 0.9409 - lr: 0.0010
Epoch 15/100
563/563 [==============================] - 22s 38ms/step - loss: 0.2515 - accuracy: 0.9100 - val_loss: 0.2452 - val_accuracy: 0.9162 - lr: 0.0010
Epoch 16/100
563/563 [==============================] - 22s 38ms/step - loss: 0.2422 - accuracy: 0.9137 - val_loss: 0.1952 - val_accuracy: 0.9344 - lr: 0.0010
Epoch 17/100
563/563 [==============================] - 22s 39ms/step - loss: 0.2375 - accuracy: 0.9148 - val_loss: 0.1441 - val_accuracy: 0.9520 - lr: 0.0010
Epoch 18/100
563/563 [==============================] - 21s 38ms/step - loss: 0.2240 - accuracy: 0.9208 - val_loss: 0.1269 - val_accuracy: 0.9611 - lr: 0.0010
Epoch 19/100
563/563 [==============================] - 21s 37ms/step - loss: 0.2097 - accuracy: 0.9278 - val_loss: 0.1954 - val_accuracy: 0.9347 - lr: 0.0010
Epoch 20/100
563/563 [==============================] - 24s 42ms/step - loss: 0.1986 - accuracy: 0.9288 - val_loss: 0.1387 - val_accuracy: 0.9504 - lr: 0.0010
Epoch 21/100
563/563 [==============================] - 22s 39ms/step - loss: 0.2008 - accuracy: 0.9296 - val_loss: 0.1841 - val_accuracy: 0.9371 - lr: 0.0010
Epoch 22/100
563/563 [==============================] - 21s 37ms/step - loss: 0.1910 - accuracy: 0.9338 - val_loss: 0.1901 - val_accuracy: 0.9360 - lr: 0.0010
Epoch 23/100
563/563 [==============================] - 21s 37ms/step - loss: 0.1878 - accuracy: 0.9367 - val_loss: 0.1580 - val_accuracy: 0.9436 - lr: 0.0010
Epoch 24/100
563/563 [==============================] - 22s 39ms/step - loss: 0.1293 - accuracy: 0.9557 - val_loss: 0.1151 - val_accuracy: 0.9640 - lr: 2.0000e-04
Epoch 25/100
563/563 [==============================] - 21s 37ms/step - loss: 0.1189 - accuracy: 0.9584 - val_loss: 0.1342 - val_accuracy: 0.9573 - lr: 2.0000e-04
Epoch 26/100
563/563 [==============================] - 21s 37ms/step - loss: 0.1095 - accuracy: 0.9638 - val_loss: 0.0909 - val_accuracy: 0.9671 - lr: 2.0000e-04
Epoch 27/100
563/563 [==============================] - 21s 37ms/step - loss: 0.1024 - accuracy: 0.9642 - val_loss: 0.1016 - val_accuracy: 0.9678 - lr: 2.0000e-04
Epoch 28/100
563/563 [==============================] - 22s 38ms/step - loss: 0.0992 - accuracy: 0.9672 - val_loss: 0.1330 - val_accuracy: 0.9569 - lr: 2.0000e-04
Epoch 29/100
563/563 [==============================] - 22s 38ms/step - loss: 0.1043 - accuracy: 0.9644 - val_loss: 0.1311 - val_accuracy: 0.9640 - lr: 2.0000e-04
Epoch 30/100
563/563 [==============================] - 21s 38ms/step - loss: 0.0965 - accuracy: 0.9658 - val_loss: 0.0948 - val_accuracy: 0.9716 - lr: 2.0000e-04
Epoch 31/100
563/563 [==============================] - 22s 38ms/step - loss: 0.0928 - accuracy: 0.9673 - val_loss: 0.1059 - val_accuracy: 0.9691 - lr: 2.0000e-04
Epoch 32/100
563/563 [==============================] - 22s 38ms/step - loss: 0.0829 - accuracy: 0.9706 - val_loss: 0.0814 - val_accuracy: 0.9778 - lr: 4.0000e-05
Epoch 33/100
563/563 [==============================] - 21s 38ms/step - loss: 0.0804 - accuracy: 0.9715 - val_loss: 0.0888 - val_accuracy: 0.9718 - lr: 4.0000e-05
Epoch 34/100
563/563 [==============================] - 22s 38ms/step - loss: 0.0830 - accuracy: 0.9719 - val_loss: 0.0932 - val_accuracy: 0.9689 - lr: 4.0000e-05
Epoch 35/100
563/563 [==============================] - 21s 37ms/step - loss: 0.0776 - accuracy: 0.9734 - val_loss: 0.0860 - val_accuracy: 0.9738 - lr: 4.0000e-05
Epoch 36/100
563/563 [==============================] - 21s 37ms/step - loss: 0.0793 - accuracy: 0.9722 - val_loss: 0.0954 - val_accuracy: 0.9702 - lr: 4.0000e-05
Epoch 37/100
563/563 [==============================] - 21s 37ms/step - loss: 0.0768 - accuracy: 0.9716 - val_loss: 0.0912 - val_accuracy: 0.9720 - lr: 4.0000e-05
Epoch 38/100
563/563 [==============================] - 22s 38ms/step - loss: 0.0763 - accuracy: 0.9734 - val_loss: 0.0929 - val_accuracy: 0.9724 - lr: 8.0000e-06
Epoch 39/100
563/563 [==============================] - 21s 37ms/step - loss: 0.0759 - accuracy: 0.9742 - val_loss: 0.0945 - val_accuracy: 0.9718 - lr: 8.0000e-06
Epoch 40/100
563/563 [==============================] - 21s 37ms/step - loss: 0.0770 - accuracy: 0.9736 - val_loss: 0.0885 - val_accuracy: 0.9751 - lr: 8.0000e-06
Epoch 41/100
563/563 [==============================] - 21s 36ms/step - loss: 0.0760 - accuracy: 0.9737 - val_loss: 0.0868 - val_accuracy: 0.9742 - lr: 8.0000e-06
Epoch 42/100
563/563 [==============================] - 21s 36ms/step - loss: 0.0756 - accuracy: 0.9717 - val_loss: 0.0865 - val_accuracy: 0.9742 - lr: 8.0000e-06
```

```python
# Create a figure and a grid of subplots with a single call
fig, (ax1, ax2) = plt.subplots(1, 2, figsize=(10,5))

# Plot the loss curves on the first subplot
ax1.plot(history.history['loss'], label='training loss')
ax1.plot(history.history['val_loss'], label='validation loss')
ax1.set_title('Loss curves')
ax1.set_xlabel('Epoch')
ax1.set_ylabel('Loss')
ax1.legend()

# Plot the accuracy curves on the second subplot
ax2.plot(history.history['accuracy'], label='training accuracy')
ax2.plot(history.history['val_accuracy'], label='validation accuracy')
ax2.set_title('Accuracy curves')
ax2.set_xlabel('Epoch')
ax2.set_ylabel('Accuracy')
ax2.legend()

# Adjust the spacing between subplots
fig.tight_layout()

# Show the figure
plt.show()
```




```python
model.save("saved_models/model")
```

```
INFO:tensorflow:Assets written to: saved_models/model\assets
INFO:tensorflow:Assets written to: saved_models/model\assets
```

4.1 Checking our model

```python
test_loss, test_acc = model.evaluate(test_ds)
print('Test accuracy (model_new):', test_acc)
```

```
79/79 [==============================] - 1s 15ms/step - loss: 0.0970 - accuracy: 0.9756
Test accuracy (model_new): 0.975600004196167
```

5. Comparing model to Google's Teachable Machine

In [ ]: